The Automatic Test Features of the IDiPS Reactor Protection System

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1. Introduction

The reactor protection system (RPS) is designed to minimize a propagation of abnormal or accident conditions of nuclear power plants. A digital RPS (Integrated Digital Protection System (IDiPS) RPS) is being developed in the Korea Nuclear Instrumentation and Control System (KNICS) R&D project.

To make good use of the advantages of the digital technology, it is necessary to improve the reliability and availability of a system through automatic test features including an on-line testing, a self-diagnostics, an auto calibration, etc.[1, 2]

This paper summarizes the system test strategy and the automatic test features of the IDiPS RPS

2. Strategy of IDiPS RPS Test

The IDiPS RPS has four channels which are located in electrically and physically isolated rooms. Each channel of the IDiPS RPS consists of a redundant structure, named as a 'two-group structure', which has two BPs (bistable processors) and two CPs(coincidence processors). Each channel has an ATIP (automatic test and interface processor), a COM (cabinet operator module) and an initiation circuit. The BP and the CP in each group are independently performed their functions and the trip signals of the CPs in each group are combined with a 1/2 logic in the initiation circuit for improving the safety. [3]

The purposes of a system testing of RPS are to provide a means to meet the periodic surveillance testing requirements specified in the USNRC Reg. Guide 1.22 and the technical specification guidelines of the nuclear plant, and to improve the availability and reliability of the system.

The IDiPS RPS test can be classified into two categories, one is an active test, and the other is a passive test. The active test consists of an automatic periodic test, a manual-initiated automatic test, and a manual test.[4] The automatic periodic test is periodically initiated by the ATIP without any human intervention. ATIP provides test input to the BP and the CP, and automatically checks the test results using the test output from the processors during the automatic periodic test. The manual initiated automatic test is almost the same as the automatic periodic test except for the operator initiation. This test is performed by a human decision, if necessary.

The test for all of the functions and components of the RPS should be overlapped not to leave any untested parts. Fig.1 represents the coverage of each test to meet the overlap requirement of a system testing.

The test to partially check a system's integrity is the passive test which consists of an on-line status diagnostics and a component self-diagnostics.

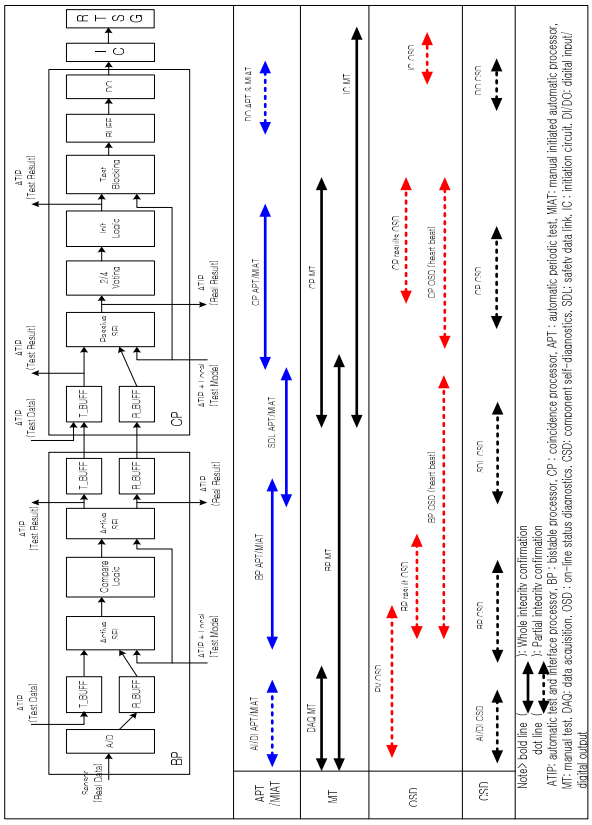

Fig 2. The coverage of each test in IDiPs RPS

3. Automatic Periodic Test Features

The automatic periodic testing consists of the BP logic test, CP logic test, safety data link test and input/output cards test. (See Fig. 2.)

The goal of the automatic periodic test is to be a major means for a periodic surveillance testing of the RPS. In addition it can improve the system reliability and availability. To implement this, we setup the following design principles; (1) The inherent safety function of the RPS is not affected by the test, (2) an unintended trip of a RPS channel do not occur due to the automatic periodic test, (3) the reliability and the availability of the RPS do not degrade during the automatic periodic test

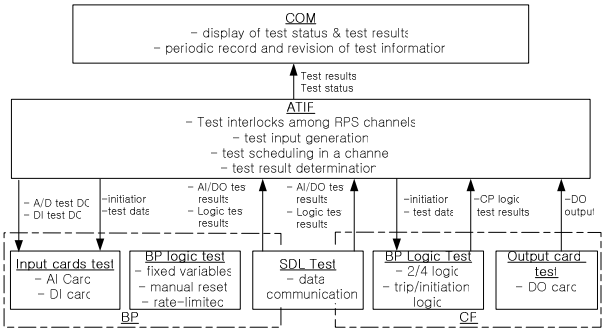

Fig 2. The functional structure of the automatic periodic test

To meet the design principles we developed the following design features. Regarding the design principle (1), the test is performed in only one channel in the RPS and performed in only one group in a channel. Each ATIP checks the test conditions of all the channels and controls the test schedule. Before starting automatic test of a channel, the ATIP in the channel transmits the test information to the ATIPs in the other channels. Each ATIP in the other channels returns the test information from their channel. If there are confirmation signals in other channels, then only, the ATIP in the test channel can initiate the automatic test. During the automatic test if there is any real trip and pre-trip condition, the BP and the CP stop the test. During the CP automatic test, the real trip signal is certainly output by the passive OR logic. Fig. 3 shows the typical CP processing logic including the automatic periodic test logic.

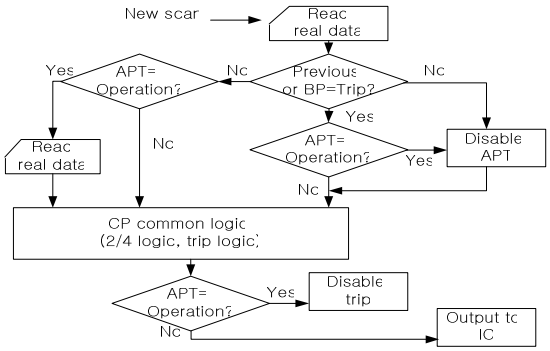

Fig 3. A typical CP processing structure including APT

Regarding the design principles (2) and (3), we developed a bypass-free automatic test feature. Although a RPS channel is executing the test, all the channels in the RPS are available. Therefore, the reliability and the availability of the RPS during the test does not degrade when compared with those of the RPS during a normal operation. During the BP automatic test, the BP simultaneously performs the real trip functions and the test functions. The BP memory is independently divided into two; one is for a real trip logic, the other is for a test logic. The ATIP provides the test data to the test memory of the BP, and then the BP processes the test logic and the real trip logic independently. The CP simultaneously processes the trip function and the test function during the automatic periodic test. In order to prevent an unintended trip due to the test signals, the logic for blocking of test trip output exists. Table 1 summarizes the test permission condition, the test prohibition condition, and the test interruption condition corresponding to the design principles.

Table 1. Automatic periodic test conditions

Comp.	System/channel Conditions	APT perm. (AND)	APT prohib (OR)	APT interup (OR)
BP	existence of trip signals in the previous scan	no	yes	yes
	doing other testing	no	yes	yes
	any BP failure	no	yes	yes
	interruption signal from the ATIP	no	N/A	yes
	initiation signal from the ATIP	yes	no	N/A
	correspondence of tested processor ID	yes	no	N/A
	time over signal	no	N/A	yes
CP	existence of trip signals from the 4 BPs	no	yes	yes
	existence of trip signals in the previous scan	no	yes	yes
	doing other testing	no	yes	yes
	CP failure	no	yes	yes
	interruption signal from the ATIP	no	N/A	yes
	initiation signal from the ATIP	yes	yes	N/A
	correspondence of tested processor ID	yes	yes	N/A
	time over signal	no	N/A	yes
	BP heartbeat error	no	yes	yes

4. Conclusion

A system test method including an automatic periodic test was developed to apply it to the IDiPS RPS. Especially, the automatic periodic test can be a means for the periodic surveillance testing of the RPS, and the test can improve system's reliability and availability. The major principle of the automatic periodic test is that the inherent safety functions of the RPS are not affected by the test, the trip bypasses of the RPS channel are not needed during the test, and an unintended trip of the RPS channel does not occur due to the test. We are implementing these test methods to the IDiPS RPS, and will verify the test logics through a design verification test.

Acknowledgements

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